INSTRUMENT CALIBRATION PROCEDURE
FOR
MONOPULSE BEACON TEST SET

FREESTATE ELECTRONICS

FS-1210

Revision 1.1 (10/17/2006)

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION 1 - INTRODUCTION AND DESCRIPTION

1.1 This procedure describes the calibration of the Freestate Electronics FS-1210 Monopulse Beacon Test Set. The instrument being calibrated is referred to herein as the TI (Test Instrument).

1.2 This procedure includes tests of essential performance parameters only. Any malfunction noticed during calibration, whether specifically tested for or not, should be corrected.

Table 1 - Calibration Description

TI Characteristics	Performance Specifications	Test Method
Power supply	Voltages (V dc): +5.0 ±0.2 V; -5.0 ±0.2 V; +15.0 ±0.25 V	Power supply voltages (internal diagnostics feature) are verified using the MBTS OCS software on the controller.
RF output	<u>Reference Signal (1060 MHz)</u> Frequency: 1060 MHz Tolerance: ±0.001 MHz Output range: +8 to –22 dBm Tolerance: ±2 dB <u>Reply Output (Sum/Delta/Omni)</u> Frequency: 1090 MHz (nominal); 1080.0 to 1100.0 MHz (adjustable range) Tolerance: ±0.001 MHz Output range: +10 to -85 dBm, Sum; +16 dBm min (nom), Delta; -10 dBm min (nom), Omni Tolerance: ±0.5 dB[1], Sum; ±2 dB, Delta and Omni (absolute), except ±1 dB at rated maximum level Delta/Sum ratio: +12 to -41.50 dB, ±1.0 dB variation between pulses in pulse train Sum/Omni ratio: +20 to -27 dB, ±1.0 dB CW/Pulsed RF ratio: CW/Pulse levels within ±0.5 dB Flatness (Pulsed RF): ≤1 dB amplitude variation between pulses in pulse train	The RF output frequency is tested using a universal counter. The RF output power levels are tested using a signal generator calibrator in the CW mode, and the CW/Pulse ratio and flatness are tested using a peak power analyzer. The output level maximum capability is tested using the signal generator calibrator, but the Delta and Omni test points are at a value 1 dB below the rated maximum to stay away from potential amplifier conflicts with the Sum output within the TI.

[1] The Sum output level is tested to a TAR as low as 1:1 at -85 dBm to as high as 2:1 at +10 dBm due to limitations of the calibration equipment for this test (signal generator calibrator).

TI Characteristics	Performance Specifications	Test Method
Interrogation Detect	Codes detected: Modes 2, 3/A, B, C	Code detection is tested by applying various codes to the TI using simulated interrogations from a signal generator modulated by a pulse generator.
Reply pulse characteristics	<u>Modes 2, 3/A, B, C</u> F1/F2 spacing: 20.3 µs ±0.1 µs Fx, Ax, Bx, Cx, Dx width: 0.45 µs ±0.1 µs Ax,Bx,Cx,Dx spacing: ±0.1 µs of nominal spacing from F1 ID of position spacing: 24.65 µs ±0.1 µs from F1 Pulse rise time: 0.05 µs – 0.1 µs Pulse fall time: 0.05 µs – 0.2 µs	Reply pulse characteristics are tested using a crystal detector and digital oscilloscope.
Trigger output	Frequency range: 10 Hz to 1 kHz Tolerance: ±2 Hz Pulse width range: 0.1 to 5.0 µs Tolerance: ±0.05 µs, 0.1 to <1.0 µs; ±0.1 µs, 1.0 to 5.0 µs	Tested using a universal counter and digital oscilloscope.

SECTION 2 - EQUIPMENT REQUIREMENTS

NOTES

Minimum use specifications are the principal parameters required for performance of the calibration, and are included to assist in the selection of alternate equipment, which may be used at the discretion of the using laboratory. Satisfactory performance of alternate items shall be verified prior to use. All applicable equipment must bear evidence of current calibration.

Table 2 - Equipment Requirements

Item	Minimum Use Specifications	Calibration Equipment
2.1 Controller	Computer with IEEE card and MBTS software	
Required Components:		
2.1.1 Controller	Computer with MBTS software	p/o TI
2.1.2 PCMCIA IEEE card	IEEE card compatible with controller	p/o TI
2.1.3 IEEE-PCMCIA cable	Interfaces IEEE-488 device with PCMCIA IEEE card	p/o TI
2.1.4 AC/DC power adapter	AC power supply that provides dc voltage to controller	p/o TI
2.1.5 Mouse (optional)	USB mouse, useful for execution of MBTS software	p/o TI
2.2 Signal generator calibrator		Hewlett-Packard 8902AOPTE51
Required Components:		
2.2.1 Measuring receiver	RF frequency range: 1060 to 1090 MHz Uncertainty: ±250 Hz (including time base uncertainty of item 2.2.3) Power range: +20 to -85 dBm Uncertainty: ±0.125 dB[1]	Hewlett-Packard 8902A
2.2.2 Sensor module	RF frequency range: 1060 to 1090 MHz Power range: +20 to -85 dBm Uncertainty: see item 2.2.1	Hewlett-Packard 11722A

[1] The standard recommended (Hewlett-Packard 8902A) does not meet the recommended uncertainty of ±0.125 dB for power measurements, but instead is capable of ±(0.25 dB + 0.03 dB/10 dB). As a consequence the TAR for the TI Sum output power tests range from 1:1 (@-85 dBm) to 2:1 (@+10 dBm). An alternate standard must at least be as accurate as the Hewlett-Packard 8902A to be utilized.

Item	Minimum Use Specifications	Calibration Equipment
2.3 Digital oscilloscope	Bandwidth: 20 MHz Vertical scale: 0.01 V/div nom. (with 50 Ω input impedance and invert capability) Uncertainty: NA Sweep speeds: 1 µs/div to 4 µs/div Uncertainty: NA Cursor gated burst width timing measurement at 50% level Uncertainty: ±25 ns Averaging capability (# of avg = 16)	Tektronix TDS5054B-NV-AV
2.4 Pulse generator	Frequency: 150 Hz nom Pulse width: 10 µs nom Output level: 5 V pk nom	Hewlett-Packard 8114AOPT001
2.5 Universal counter	Time interval measurement range: 5.0 µs to 3200 µs Uncertainty: ±0.06 µs, ≤25 µs; ±0.4 µs, >25 µs Frequency measurement range: 10 to 1000 Hz Uncertainty: ±2 Hz Pulse width measurement range: 0.1 to 5.0 µs Uncertainty: ±12.5 ns, <1.0 µs; ±25 ns, ≥1.0 µs	Hewlett-Packard 53132AOPT010,030
2.6 Signal generator	Frequency use: 1030 MHz Uncertainty: ±0.001% Output level: +5 dBm nom External pulse modulation capability	Hewlett-Packard 8648BOPT1EA,1E2, 1E5,1E6,H31
2.7 Termination	Impedance: 50 Ω nom Type: Feedthrough Connectors: BNC	Tektronix 011-0099-00
2.8 Adapter	Type: N(m)-N(m)	Obtain locally
2.9 RF coaxial cable	Connectors: Type N(m)	Obtain locally
2.10 BNC cable (2 required)	Connectors: BNC(m) Length: 3 to 6 ft recommended	Obtain locally
2.11 Crystal detector	Frequency use: 1090 MHz	Hewlett-Packard 8470BOPT012

SECTION 3 - PRELIMINARY OPERATIONS

3.1 Ensure that all power switches are set to off, and set all auxiliary equipment controls as necessary to avoid damage to the equipment and so that dangerous voltages will not be present on output terminals when the power switches are turned on.

3.2 Connect the test equipment (except TI and controller) to the appropriate power source.

3.3 Turn all test equipment power switches on and allow sufficient warm-up time for the equipment. (Perform the TI Setup and Initialization starting at step 3.4 while waiting for the test equipment to warm up.)

3.4 TI Setup and Initialization

3.4.1 Ensure that the PCMCIA IEEE card is installed in the controller (item 2.1.1).

3.4.2 Connect the equipment as shown in Figure 1. (Leave this configuration connected for the rest of the procedure.)

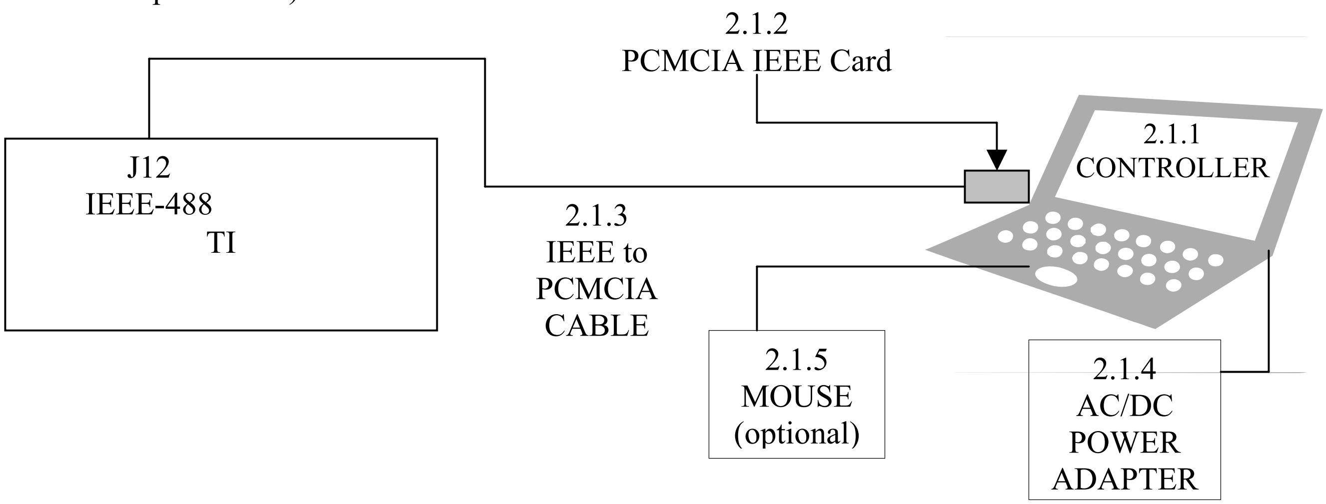

Figure 1 - TI/Controller Interconnection Diagram

3.4.3 Turn on the controller and wait until the controller has fully booted to the windows screen.

3.4.3.1 If, during boot up, the controller displays a “Log On to Windows” box, enter “Tech2” for both the username and password. (Note: capitalization matters for the password. If the username/password provided doesn’t work, contact the TI user.)

3.4.4 Set the TI **POWER** switch to ON. During turn on the TI PLL LOCK lamps (Built In Test module, Reply Generator module, IDR module, and Reference Source module) will first display Red and then switch to Green once the phase locked loop has been established. Upon completion of the built-in-test (BIT) diagnostics the PROC lamp should turn on (green) and off once every second.

3.4.5 Verify that once the BIT diagnostics have completed the TI Process Control and Communications module BIT lamp and all of the Built In Test module lamps are illuminated green.

3.4.6 On the controller screen, select the MBTS OCS icon (double-click) or alternatively access

"Start/Programs/MBTS OCS/MBTS OCS". (Note: the exact name of the icon and/or the MBTS OCS folder/software name may vary due to version differences.)

3.4.7 Upon startup the MBTS OCS software will automatically verify the IEEE connection between the controller and the TI, and will load default operational parameters. When the Azimuth Gated Target option is Green (without a 'grayed' unselected look) the MBTS OCS software is ready for use.

NOTES

During initialization of the MBTS OCS software, if it appears that the software has 'locked up' (visible by the Operating Mode selections never becoming enabled), shut down the MBTS OCS software, turn off the TI, and then restart the TI initialization process starting at step 3.4.4.

Also, during initialization of the MBTS OCS software, if there are any GPIB problems (either by error message or the failure of the software to display a MBTS version), shut down the MBTS OCS software, turn off the TI, turn off the controller, ensure the IEEE card is seated properly in the controller and the IEEE to PCMCIA cable is properly attached between the controller and the TI, and then restart the controller and TI initialization process starting at step 3.4.3.

For reference, to turn off the MBTS OCS software, select the Green ON button at the top left of the software.

To change MBTS OCS software options or numerical values, either click on the option itself (which may produce a popup list of alternate options) to change its state, or for numerical values click on the up/down arrows next to the value or change the value by selecting the value and using the controller numerical keys to change it to the desired value followed by the Enter key.

3.4.8 By default the TI should have an IEEE address of 1 (one). If there is an IEEE bus error or for some reason the TI IEEE address has changed the MBTS software may display an error during initialization ("GPIB TIMEOUT OCCURRED"). If this occurs, first check the IEEE bus connection between the controller and the TI, or if all else fails try changing the MBTS -GPIB ADDRESS (upper left of software) to a different value until the error goes away. (Note: The error message will have to be closed before the address can be changed, and the software will redisplay the error message every few seconds as long as the error condition remains.)

3.4.9 Ensure that the MBTS OCS software appears similar to that shown as follows (certain settings may differ from the example):

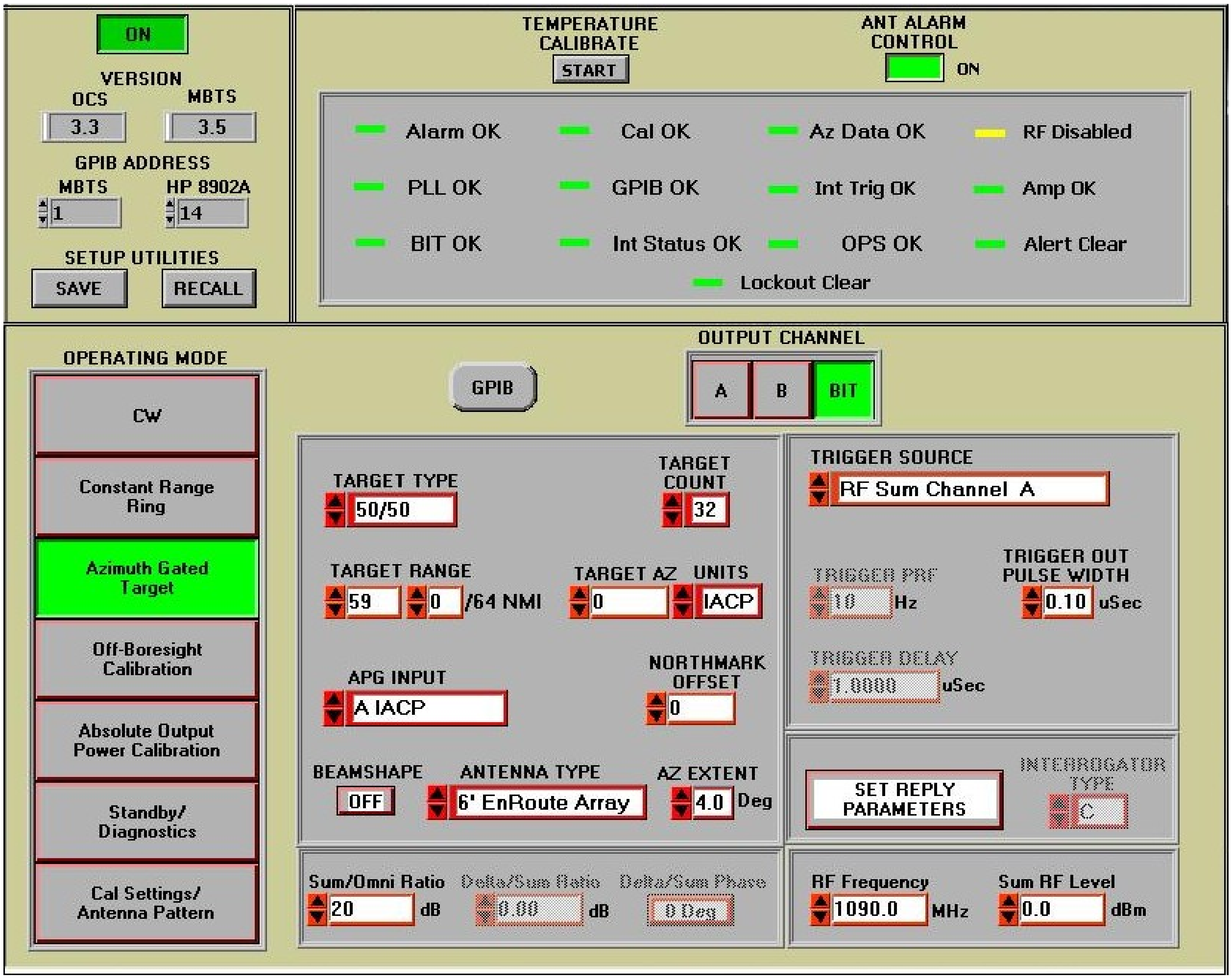

Figure 2 - MBTS OCS Software Sample Display (Initial)

3.4.10 Ensure that the OCS software VERSION is at least 3.3 and the MBTS software VERSION is at least 3.5. (These are found in the top left of the software.) (This calibration procedure was developed around the indicated versions of the software and other versions may impact the execution of this procedure.)

3.4.11 Set the MBTS OCS software ANT ALARM CONTROL setting to OFF (top right of software).

NOTES

The TI normally looks for an Antenna to be connected to it before it will allow an output to be generated. The MBTS OCS software ANT CONTROL ALARM setting must be set to OFF before testing can begin.

When pressing the MBTS OCS software ANT CONTROL ALARM button, it may not stay in the OFF position and return to the ON position, or may even end up in a flip-flop state where it alternates between the ON and OFF states. Preferably, the ANT CONTROL ALARM setting should be in the solid OFF position, but in some cases if it is flashing between ON and OFF it may settle into the OFF position once an output is turned on. If the flip-flop state exists, the Az Error and OPS Suspend flags on the main software display are affected.

3.4.12 Perform a temperature calibration by pressing the MBTS OCS software TEMPERATURE CALIBRATE – START button.

NOTE

The temperature calibration performs an internal ‘alignment’ of the TI output level to the current temperature. Upon turn on the TI ‘Cal …’ flag may be yellow and indicate “Cal Output”. This implies the temperature calibration should be performed to ensure output levels are accurate for the current temperature. If during the execution of the procedure the ‘Cal …’ flag changes from “Cal OK” to “Cal Output” perform the temperature alignment by pressing the TEMPERATURE CALIBRATE – START button.

3.4.13 Diagnostics Tests

3.4.14 Select the Standby/Diagnostics option under OPERATING MODE on the MBTS OCS software.

3.4.15 Wait until the “Loading Current Values” flashing indication disappears before proceeding.

3.4.16 Verify that the MBTS OSC software +5 VOLTS indication is between 4.800 and 5.200.

3.4.17 Verify that the MBTS OSC software -5 VOLTS indication is between -4.800 and -5.200.

3.4.18 Verify that the MBTS OSC software +15 VOLTS indication is between 14.750 and 15.250.

3.4.19 Verify that the MBTS OSC software STATUS REGISTER flag indications are all green. (The Antenna Rotation ALARM and APG ALARM flags are affected by the state of the ANT ALARM CONTROL setting. Ignore these particular flags.)

3.4.20 Select “Start BER” and run for a minimum of 20,000 samples. Verify there are zero errors indicated.

3.4.21 Select “Stop BER.”

3.4.22 Initialize the measuring receiver (item 2.2.1), and sensor module (item 2.2.2) in accordance with Appendix A.

SECTION 4 - CALIBRATION PROCESS

NOTES

The front panel BNC and Type N input/output connectors should have the accompanying terminating or protective caps connected when not in use. Throughout this procedure, replace the terminator/cap on the applicable connector after disconnecting a test setup involving one of these connectors.

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met before proceeding.

Whenever any TI setting is changed (using the MBTS OCS software) there can be a several second delay (sometimes greater than 10 seconds) until the TI has finally settled to the desired setting (this delay can be even longer if the up/down arrows are used). Whenever a TI setting is changed, wait a moment for the TI to stabilize to the new value before proceeding.

4.1 REFERENCE SIGNAL (1060 MHz) TESTS

4.1.1 Select the CW option under OPERATING MODE on the MBTS OCS software (CW mode highlighted green).

4.1.2 Ensure that the MBTS OCS software indicates that the OUTPUT CHANNEL is set to BIT (Green) and the 1060 MHZ REFERENCE SIGNAL OUTPUT is set to DISABLED (yellow).

4.1.3 Ensure that the MBTS OCS software ANT ALARM CONTROL setting is OFF (yellow). If not, and the ANT ALARM CONTROL is flashing between OFF and ON, perform the following; otherwise, press the ANT ALARM CONTROL button to set it to OFF or a flashing state and perform the following:

4.1.3.1 Set the MBTS OCS software OUTPUT CHANNEL to A and after a moment there should be an audible click indicating the output switch is activated. Once this occurs, the ANT ALARM CONTROL should now stay a solid OFF (yellow), and the Az Data OK and OPS OK should now turn solid green.

4.1.3.2 Once the MBTS OCS software ANT ALARM CONTROL is set to OFF, set the MBTS OCS software OUTPUT CHANNEL back to BIT (an audible click will indicate the output switch shutting off).

4.1.4 Connect the sensor module input to the TI (front panel) Reference Source module 1060 MHz OUTPUT (J25) connector.

4.1.5 Set the MBTS OCS software 1060 MHZ REFERENCE SIGNAL OUTPUT to ENABLED (Green).

NOTE

Whenever the MBTS OCS software OUTPUT CHANNEL setting is changed there may be a several second delay until the output is actually switched to the desired setting.

4.1.6 Activate the measuring receiver instrument preset function (Blue Shift key and Green **AUTOMATIC OPERATION** key), and ensure that the measuring receiver is set for RF frequency measurements.

4.1.7 Set the measuring receiver frequency resolution to 100 Hz (enter **7.2 SPCL**).

NOTE

If the measuring receiver has trouble ‘auto-tuning’ to the expected 1060 MHz test frequency, set the measuring receiver to manually tune to it by entering **1060 MHz**. When the measurement is completed return the measuring receiver to the auto tune mode by pressing the **AUTOMATIC OPERATION** key.

4.1.8 Verify that the measuring receiver indication is between 1059.9990 and 1060.0010 MHz.

4.1.9 Set the measuring receiver measurement mode to RF Power with log (dBm) display. (To speed measurements, ensure that the measuring receiver power resolution is set to 0.01 dB; enter **32.0 SPCL**, if necessary, to set 0.01 dB resolution.)

4.1.10 Set the MBTS OCS software 1060 MHZ OUTPUT LEVEL to each of the following values. At each setting, allow sufficient time for the TI to settle to the new level and then verify that the measuring receiver indication is within the tolerance limits listed in the following table.

NOTE

Whenever the TI output level is changed there may be a several second delay (which can be greater than 10 seconds) until the output level has finally settled to the desired setting (longer if the up/down arrows are used). Wait until the power level has stabilized to the new value for a period of time before verifying the measurement.

MBTS OCS Software *1060 MHZ OUTPUT LEVEL* Setting (dBm)	Measuring Receiver Tolerance Limits (dBm)
8	6.0 to 10.0
5	3.0 to 7.0
0	-2.0 to +2.0
-5	-3.0 to -7.0

4.1.11 Set the measuring receiver measurement mode to Tuned RF Level measurements with log (dBm) display and clear any current range-to-range calibration factors (enter **39.9 SPCL** and press the **CALIBRATE** key).

4.1.12 Set the MBTS OCS software 1060 MHZ OUTPUT LEVEL to each of the following values. At each setting, allow sufficient time for the TI to settle to the new level and then verify that the measuring receiver indication is within the tolerance limits listed in the following table.

NOTE

Whenever the TI output level is changed there may be a several second delay (which can be greater than 10 seconds) until the output level has finally settled to the desired setting (longer if the up/down arrows are used). Wait until the power level has stabilized to the new value for a period of time before verifying the measurement.

MBTS OCS Software *1060 MHZ OUTPUT LEVEL* Setting (dBm)	Measuring Receiver Tolerance Limits[1] (dBm)
-10	-8.0 to -12.0
-15	-13.0 to -17.0
-22	-20.0 to -24.0

[1] If at any time the measuring receiver indicates RECAL, first wait for the display indication to settle, press the **CALIBRATE** key, and then wait for the measuring receiver to return with a measurement value before proceeding.

4.1.13 Set the MBTS OCS software 1060 MHZ OUTPUT LEVEL to 8 dBm.

4.1.14 Set the MBTS OCS software 1090 MHZ CW OUTPUT to ENABLED (Green).

4.1.15 Disconnect the sensor module from the TI.

4.2 REPLY OUTPUT FREQUENCY TESTS

4.2.1 Ensure that the MBTS OCS software indicates that the OUTPUT CHANNEL is set to BIT and the 1090 MHZ CW OUTPUT is set the ENABLED (Green).

4.2.2 Ensure that the MBTS OCS software ANT ALARM CONTROL setting is OFF (yellow).

4.2.3 Connect the sensor module input to the TI (rear panel) "Σ" (sum) CHANNEL A (J1) connector.

4.2.4 Ensure that the MBTS OCS software Sum RF Level is set to 0.0 dBm.

4.2.5 Set the MBTS OCS software OUTPUT CHANNEL to A (an audible click will indicate the output turning on).

NOTE

Whenever the MBTS OCS software OUTPUT CHANNEL is changed there may be a several second delay until the output is actually switched to the desired setting.

4.2.6 Activate the measuring receiver instrument preset function (Blue Shift key and Green **AUTOMATIC OPERATION** key), and ensure that the measuring receiver is set for RF frequency measurements.

4.2.7 Set the measuring receiver frequency resolution to 100 Hz (enter **7.2 SPCL**).

NOTE

If the measuring receiver has trouble 'auto-tuning' to the following test frequencies, set the measuring receiver to manually tune to it by entering the test frequency followed by the

MHz key. When the current measurement is completed return the measuring receiver to the auto tune mode for the next measurement by pressing the **AUTOMATIC OPERATION** key.

4.2.8 Verify that the measuring receiver indication is between 1089.9990 and 1090.0010 MHz.

4.2.9 Set the MBTS OCS software RF Frequency to 1085.0. MHz.

NOTE

Whenever the MBTS OCS software RF Frequency is changed there may be a several second delay (can be greater than 10 seconds) until the output frequency has finally settled to the desired setting.

4.2.10 After allowing sufficient time for the TI to settle to the '1085.0 MHz' frequency setting, verify that the measuring receiver indication is between 1084.9990 and 1085.0010 MHz.

4.2.11 Set the MBTS OCS software RF Frequency to 1095.0. MHz.

4.2.12 After allowing sufficient time for the TI to settle to the '1095.0 MHz' frequency setting, verify that the measuring receiver indication is between 1094.9990 and 1095.0010 MHz.

4.2.13 Set the MBTS OCS software RF Frequency to 1090.0. MHz.

4.3 REPLY OUTPUT CW OUTPUT LEVEL/RATIO TESTS

4.3.1 Sum Output Level Channel A Tests

4.3.1.1 Set the measuring receiver measurement mode to RF Power with log (dBm) display.

4.3.1.2 Set the MBTS OCS software Sum RF Level to each of the following values. At each setting, allow sufficient time for the TI to settle to the new level and then verify that the measuring receiver indication is within the tolerance limits listed in the following table.

NOTE

Whenever the TI output level is changed there may be a several second delay (which can be greater than 10 seconds) until the output level has finally settled to the desired setting (longer if the up/down arrows are used). Wait until the power level has stabilized to the new value for a period of time before verifying the measurement.

MBTS OCS Software *Sum RF* Level Setting (dBm)	Measuring Receiver Tolerance Limits (dBm)
10.0	9.5 to 10.5
5.0	4.5 to 5.5
0.0	-0.5 to +0.5

-5.0	-4.5 to –5.5

4.3.1.3 Set the measuring receiver measurement mode to Tuned RF Level measurements with log (dBm) display and clear any current range-to-range calibration factors (enter **39.9 SPCL** and press the **CALIBRATE** key).

4.3.1.4 Set the MBTS OCS software Sum RF Level to each of the following values. At each setting, allow sufficient time for the TI to settle to the new level and then verify that the measuring receiver indication is within the tolerance limits listed in the following table.

NOTE

Whenever the TI output level is changed there will be a several second delay (which can be greater than 10 seconds) until the output level has finally settled to the desired setting (longer if the up/down arrows are used). Wait until the power level has stabilized to the new value for a period of time before verifying the measurement.

MBTS OCS Software *Sum RF Level* Setting (dBm)	Measuring Receiver Tolerance Limits[2] (dBm)
-10.0	-9.5 to -10.5
-20.0	-19.5 to -20.5
-30.0	-29.5 to -30.5
-40.0	-39.5 to -40.5
-50.0	-49.5 to -50.5
-60.0	-59.5 to -60.5
-70.0	-69.5 to -70.5
-85.0	-84.5 to -85.5

[2] If at any time the measuring receiver indicates RECAL, first wait for the display indication to settle, press the **CALIBRATE** key, and then wait for the measuring receiver to return with a measurement value before proceeding.

4.3.2 Delta/Sum Ratio Channel A Tests

4.3.2.1 Set the MBTS OCS software Sum RF Level to -15.0 dBm.

4.3.2.2 Set the MBTS OCS software Delta/Sum Ratio to 12.00 dB.

4.3.2.3 Set the measuring receiver for ratio (relative dB) measurements (press the DISPLAY – **RATIO** key as necessary for 0.00 ±0.02 dB REL indication).

4.3.2.4 Activate the measuring receiver range hold function (press the **RANGE HOLD** key – illuminated).

4.3.2.5 Set the MBTS OCS software OUTPUT CHANNEL to BIT (Green).

4.3.2.6 Move the sensor module input to the TI (rear panel) "Δ" (delta) CHANNEL A (J2) connector.

4.3.2.7 Set the MBTS OCS software OUTPUT CHANNEL to A.

4.3.2.8 Deactivate the measuring receiver range hold function (press the **RANGE HOLD** key - extinguished).

4.3.2.9 Set the MBTS OCS software Delta/Sum Ratio to each of the following values. At each setting, allow sufficient time for the TI to settle to the new level and then verify that the measuring receiver indication is within the tolerance limits listed in the following table.

NOTE

Whenever the TI output level is changed there will be a several second delay (which can be greater than 10 seconds) until the output level has finally settled to the desired setting (longer if the up/down arrows are used). Wait until the power level has stabilized to the new value for a period of time before verifying the measurement.

MBTS OCS Software *Delta/Sum Ratio* Setting (dB)	Measuring Receiver Tolerance Limits (dB)
12	11.0 to 13.0
0.0	-1.0 to +1.0
-10.0	-9.0 to -11.0
-20.0	-19.0 to -21.0
-30.0	-29.0 to -31.0

4.3.3 Sum/Omni Ratio Channel A Tests

4.3.3.1 Activate the measuring receiver range hold function (press the **RANGE HOLD** key – illuminated).

4.3.3.2 Set the MBTS OCS software OUTPUT CHANNEL to BIT (Green).

4.3.3.3 Move the sensor module input to the TI (rear panel) "Σ" (sum) CHANNEL A (J1) connector.

4.3.3.4 Set the MBTS OCS software OUTPUT CHANNEL to A.

4.3.3.5 Deactivate the measuring receiver range hold function (press the **RANGE HOLD** key - extinguished).

4.3.3.6 Set the MBTS OCS software Sum RF Level to -40.0 dBm.

4.3.3.7 Set the MBTS OCS software Sum/Omni Ratio to 20 dB.

4.3.3.8 Set the measuring receiver for ratio (relative dB) measurement (press the DISPLAY – **RATIO** key as necessary for 0.00 ±0.02 dB REL indication).

4.3.3.9 Activate the measuring receiver range hold function (press the **RANGE HOLD** key – illuminated).

4.3.3.10 Set the MBTS OCS software OUTPUT CHANNEL to BIT (Green).

4.3.3.11 Move the sensor module input to the TI (rear panel) "Ω" (omni) CHANNEL A (J3) connector.

4.3.3.12 Set the MBTS OCS software OUTPUT CHANNEL to A.

4.3.3.13 Deactivate the measuring receiver range hold function (press the **RANGE HOLD** key - extinguished).

4.3.3.14 Set the MBTS OCS software Sum/Omni Ratio to each of the following values. At each setting, allow sufficient time for the TI to settle to the new level and then verify that the measuring receiver indication is within the tolerance limits listed in the following table.

NOTE

Whenever the TI output level is changed there will be a several second pause (which can be greater than 10 seconds) until the output level has finally settled to the desired setting. Wait until the power level has stabilized to the new value for a period of time before verifying the measurement.

MBTS OCS Software *Sum/Omni Ratio* Setting (dB)	Measuring Receiver Tolerance Limits (dB)
20	-19.0 to -21.0
10	-9.0 to -11.0
0	-1.0 to +1.0
-10	9.0 to 11.0
-20	19.0 to 21.0

4.3.3.15 Set the MBTS OCS software OUTPUT CHANNEL to BIT (Green).

4.3.3.16 Press the MBTS OCS software 1090 MHZ CW OUTPUT button. [The button should change to DISABLED (Yellow) for a moment and then back to ENABLED (Green). If it doesn't change back to ENABLED (Green), press the button as necessary to return it to the Green state.]

NOTE

Pressing the TI 1090 MHZ CW OUTPUT button resets the Sum RF Level, the Sum/Omni Ratio, and the Delta/Sum Ratio back to their default values.

4.3.4 Output Level Channel B Tests

4.3.4.1 Set the measuring receiver measurement mode to RF Power with log (dBm) display.

4.3.4.2 Move the sensor module input to the TI (rear panel) "Σ" (sum) CHANNEL B (J4) connector.

4.3.4.3 Set the MBTS OCS software OUTPUT CHANNEL to B.

4.3.4.4 Ensure that the MBTS OCS software Sum RF Level is set to 0.0 dBm.

4.3.4.5 Verify that the measuring receiver indication is between -0.5 and +0.5 dBm.

4.3.4.6 Set the MBTS OCS software OUTPUT CHANNEL to BIT (Green).

4.3.4.7 Move the sensor module input to the TI (rear panel) "Δ" (delta) CHANNEL B (J5) connector.

4.3.4.8 Set the MBTS OCS software OUTPUT CHANNEL to B.

4.3.4.9 Ensure that the MBTS OCS software Delta/Sum Ratio is set to 0.00 dB.

4.3.4.10 Verify that the measuring receiver indication is between -1.0 and +1.0 dBm.

4.3.4.11 Set the MBTS OCS software OUTPUT CHANNEL to BIT (Green).

4.3.4.12 Move the sensor module input to the TI (rear panel) "**Ω**" (omni) CHANNEL B (J6) connector.

4.3.4.13 Set the MBTS OCS software OUTPUT CHANNEL to B.

4.3.4.14 Ensure that the MBTS OCS software Sum/Omni Ratio is set to 10 dB.

4.3.4.15 Verify that the measuring receiver indication is between -9.0 and -11.0 dBm.

4.3.4.16 Set the MBTS OCS software OUTPUT CHANNEL to BIT (Green).

4.3.4.17 Disconnect the sensor module from the TI.

4.4 MODE DETECTION

4.4.1 Connect the equipment as shown in Figure 3

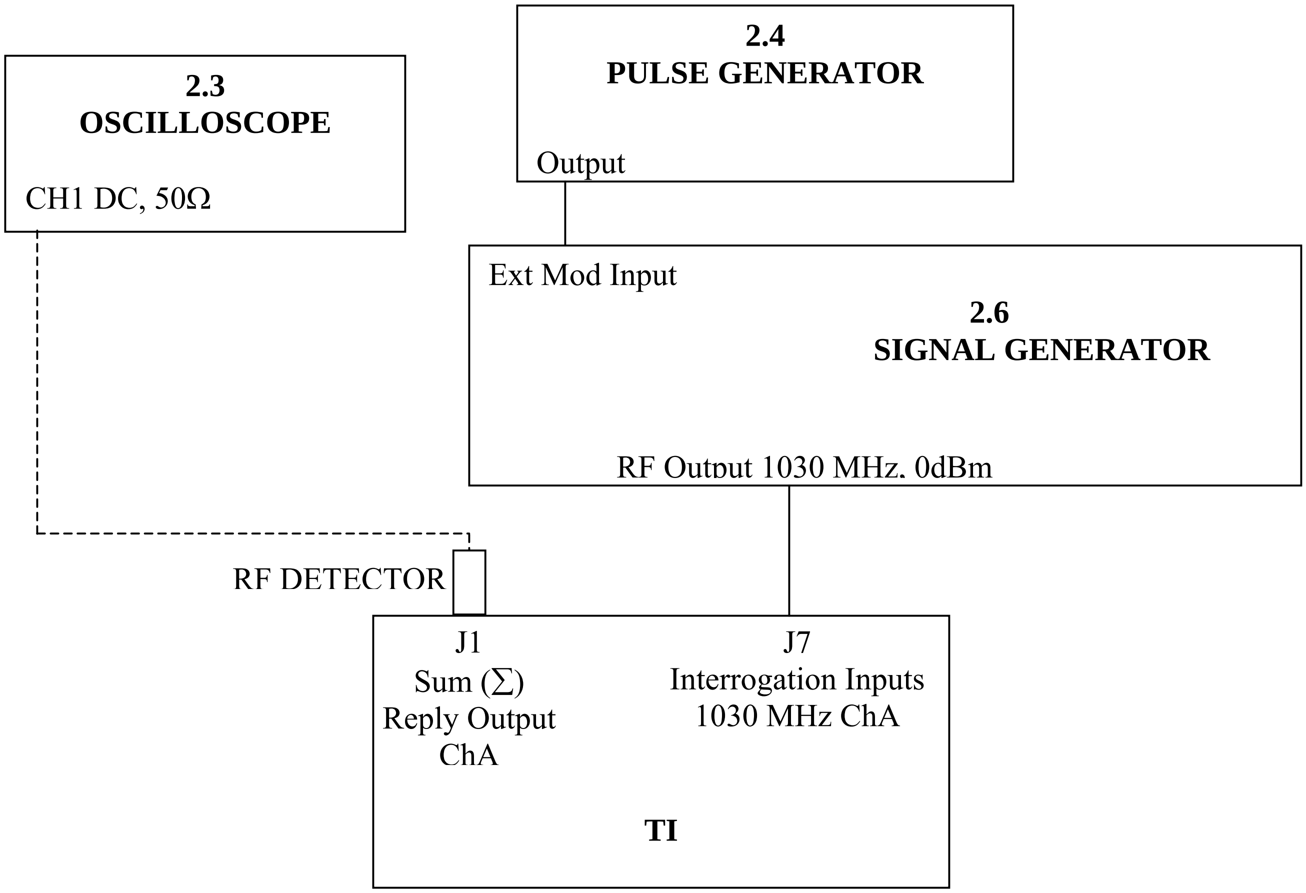

Figure 3 - Mode Detection and Reply Characteristics Test Configuration

4.4.2 Set the MBTS OCS software *Azimuth Gated Target* parameters as follows:

Select *SET REPLY PARAMETERS*
Mode 2 Code - 7777
Mode 2 SPI - ON
Mode 3/A Code - 7777
Mode 3/A SPI - ON
Mode C Code - 7777
Mode C SPI - ON
Mode B Code - 7777
Mode B SPI - ON
Select Return
Target Type - ATCRBS
Trigger Source - 1030 MHz Input Channel A
Output Channel - A

4.4.3 Set Pulse Generator as follows:
Pulse Width – 0.8 microseconds
Amplitude – 1 Vpk
Frequency (Pulse Spacing) – According to list below

Pulse Generator Frequency	TI Mode Detect Lamp Illuminated	TI Mode Reply Lamp Illuminated
200 kHz	2	2
125 kHz	3/A	3/A
58.8 kHz	B	B
47.6 kHz	C	C

4.4.4 For each frequency, verify that the corresponding TI MODE DETECT and REPLY lamps are illuminated. Ensure Antenna Alarm Control is OFF

4.4.5 Change OCS Output Channel to B and Trigger Source to 1030 MHz Input Channel B.

4.4.6 Move Signal Generator RF Output to J8 (Interrogation Input Ch B) on the TI, and move the RF detector to J4 (Sum Reply Output Ch B).

4.5 REPLY PULSE CHARACTERISTICS (Operational Verification)

4.5.1 Table X shows nominal values for reply pulse characteristics. Using Figure 3 and Table X check Reply Pulse Characteristics on the oscilloscope for each interrogation mode. On the OCS, adjust the Sum RF Level to higher amplitude if necessary.

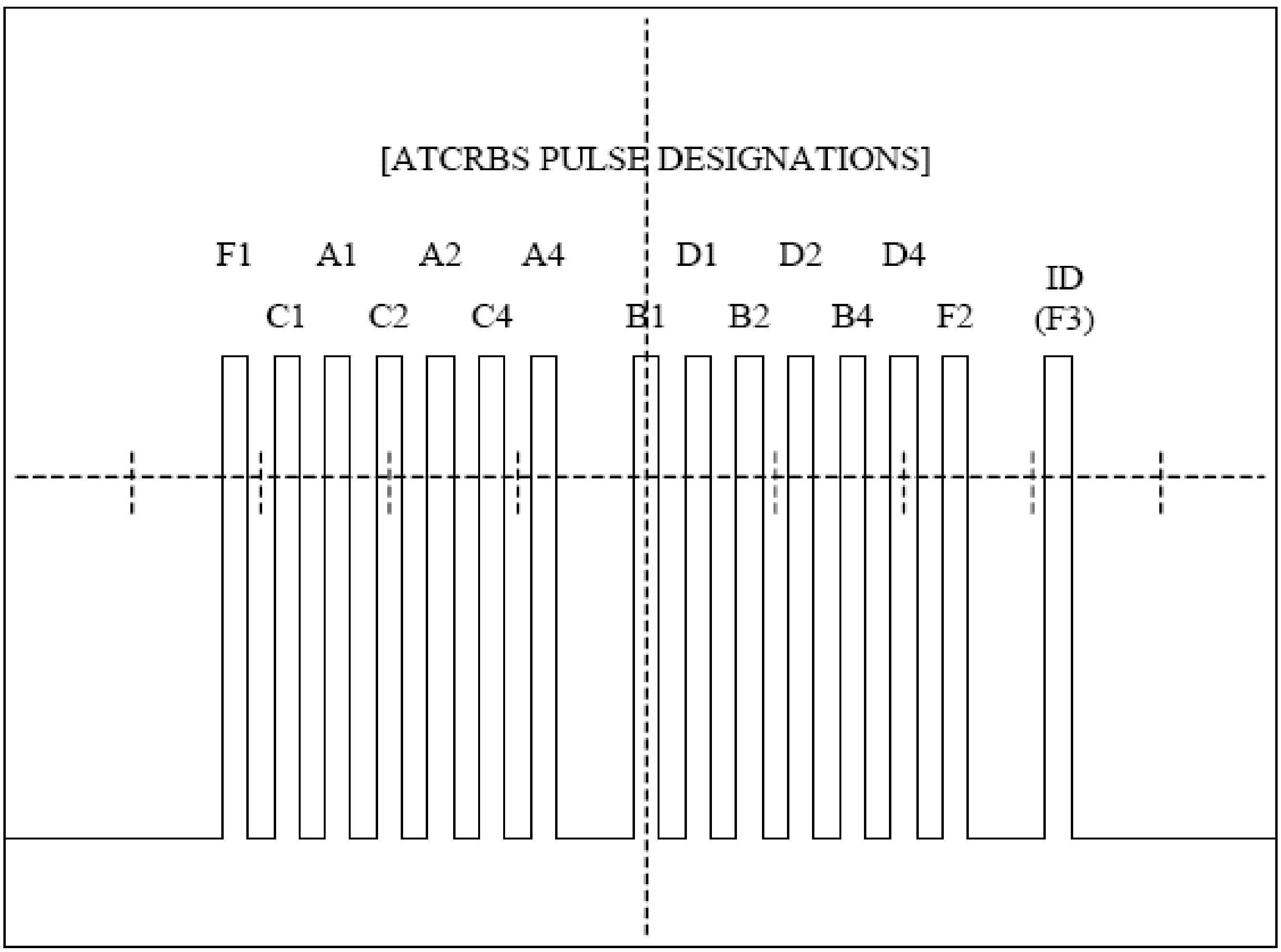

Figure 4 - Sample ATCRBS Reply

Table 3 - Reply Pulse Characteristics[3]

Reply Pulse	Pulse Width	Rise Time	Fall Time	Pulse Position from F1 (lead edge to lead edge)
C1	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	1.45μs
A1	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	2.9μs
C2	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	4.35μs
A2	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	5.8μs
C4	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	7.25μs
A4	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	8.7μs
B1	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	11.6μs
D1	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	13.05μs
B2	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	14.5μs
D2	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	15.95μs
B4	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	17.4μs
D4	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	18.85μs
F2	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	20.3μs
F3	0.45μs	0.05 – 0.1μs	0.05 – 0.2μs	24.65μs

[3]Reply pulse characteristics contained in this table are in accordance with Order 1010.51A U.S. National Aviation Standard for The IFF Mark X (SIF)/Air Traffic Control Radar Beacon System Characteristics.

4.4 INTERNAL TRIGGER TESTS

4.5.2 Connect the universal counter CHANNEL 1 input to the TI front panel TRIG OUT (J16) connector.

4.5.3 Select the Constant Range Ring option under OPERATING MODE on the MBTS OCS software (Constant Range Ring mode highlighted green).

4.5.4 Set the MBTS OCS software *Constant Range Ring* screen parameters as follows:

Trigger Source – Internal
Trigger PRF – 10 Hz
Trigger Out Pulse Width – 0.1μs

4.5.5 Cycle the universal counter power to perform an instrument preset of the device.

4.5.6 Set the universal counter controls as follows to measure the frequency of the TI trigger signal using frequency measurements, with Channel 1 set for 0.5 V trigger level, 50 Ω input impedance, and dc coupling:

MEASURE – **Freq & Ratio** key	FREQUENCY 1
CHANNEL 1 -**Trigger/Sensitivity** key	AUTO TRG: OFF
	LEVEL: .500 V (**Enter)**
	Hit Trigger/Sensitivity key again
CHANNEL 1 -**50Ω/1MΩ** key	50Ω (lamp lit)
CHANNEL 1 -**DC/AC** key	DC (lamp lit)

4.5.7 Set the MBTS OCS software TRIGGER PRF to each of the following settings. At each setting, first wait a moment for the TI to settle to the new TRIGGER PRF setting, then press the universal counter **Run** key and verify that the universal counter indication is within the following tolerance limits.

MBTS OCS Software *TRIGGER PRF* Setting (Hz)	Universal Counter Tolerance Limits (Hz)
10	8.0 to 12.0
100	98.0 to 102.0
1000	998.0 to 1002.0

4.5.8 Disconnect universal counter and replace with oscilloscope.

4.5.9 Set the oscilloscope controls to measure the pulse width of the TI trigger signal.

4.5.10 Set the MBTS OCS software TRIGGER OUT PULSE WIDTH to each of the following settings. At each setting, first wait a moment for the TI to settle to the new TRIGGER OUT PULSE WIDTH setting, and using the oscilloscope verify the indication is within the following tolerance limits.

MBTS OCS Software TRIGGER OUT PULSE WIDTH Setting (μs)	Oscilloscope Tolerance Limits (μs)
0.1	0.050 to 0.150
1.0	0.900 to 1.100
5.0	4.900 to 5.100

4.5.11 Prior to turning off the TI, first exit the MBTS OCS software by selecting the Green ON button at the top left of the software.

4.5.12 Unless other measurements are to be performed, set all power switches to off or standby and disconnect the equipment from the TI.

APPENDIX A - SIGNAL GENERATOR CALIBRATOR INITIALIZATION

A.1 Signal Generator Calibrator Interconnection

NOTE

For this procedure, the signal generator calibrator does not specifically require the 11722 series microwave converter (mixer), since all measurements are being made below 1.3 GHz. The only reference to the mixer is in the situation where it is normally used in the RF input path of the sensor module connection to the measuring receiver. The sensor module can be connected directly to the measuring receiver or through the mixer, depending upon local configuration issues.

A.1.1 Ensure that the sensor module is connected to the measuring receiver (and mixer), as applicable.

A.2 Measuring Receiver and Sensor Module Zeroing and Reference Calibration

A.2.1 Activate the measuring receiver instrument preset function (Blue Shift key and Green **AUTOMATIC OPERATION** key), and set the measuring receiver to measure RF POWER (by pressing the **RF POWER** key).

A.2.2 Enable the appropriate measuring receiver internal calibration factor Table (containing the calibration factors for the sensor module) after reading the following information.

a. By default, after an instrument preset, the measuring receiver uses the internal Table 1.
b. Typically, the calibration factor data for an 11722 sensor module is located in the internal Table 2 (but a portion of it may be in Table 1).
c. If the calibrator factor data for the 11722 sensor module being used is present in Table 2, then to ensure enabling of the Table 2 internal calibration factor data, enter **27.1 SPCL** (activates frequency offset mode) prior to any RF power measurements (including the zeroing and reference calibration).
d. If the calibrator factor data for the 11722 sensor module being used is present in some fashion in Table 1 and there is a desire to use Table 1, then to ensure enabling of the Table 1 internal calibration factor data, enter **27.0 SPCL** prior to any RF power measurements (including the zeroing and reference calibration).
e. If it is necessary to confirm that the calibration factor data (stored in either of the two internal Tables in the measuring receiver) is correct and matches the sensor module connected to the measuring receiver, refer to subsection A.3 of Appendix A. (To ensure access of the internal Table 1 calibration factor data, enter **27.0 SPCL** on the measuring receiver prior to data entry/retrieval; otherwise, to ensure access of the internal Table 2 calibration factor data, enter **27.1 SPCL** on the measuring receiver prior to data entry/retrieval.)

A.2.3 Connect the sensor module input to the measuring receiver RF POWER output.

A.2.4 Press the measuring receiver **ZERO** key and after the measuring receiver momentarily displays 0.000 W followed by a small measurement value, press the **CALIBRATE** key (to turn on the 1 mW reference).

A.2.5 Select the measuring receiver SAVE CAL function (Blue Shift key and **CALIBRATE** key) and then press the **CALIBRATE** key (to turn off the 1 mW reference). The sensor module is now zeroed and reference calibrated.

A.2.6 Disconnect the sensor module from the measuring receiver RF POWER output.

A.2.6.1 If checking the calibration factors stored in the measuring receiver Table 1, set the measuring receiver to the non-frequency offset mode by entering **27.0 SPCL**.

NOTE

The measuring receiver and sensor module zero and reference calibration procedure (steps A.2.3 through A.2.6) should be performed at least every 8 hours.

A.2.7 Return to the appropriate step in the calibration procedure.

A.3 Measuring Receiver Calibration Factor Data Check/Entry Procedure

A.3.1 Checking Calibration Factor Data

A.3.1.1 If checking the calibration factors stored in the measuring receiver Table 2, set the measuring receiver to the frequency offset mode by entering **27.1 SPCL**.

A.3.1.2 Press the measuring receiver Green **AUTOMATIC OPERATION** and **RF POWER** keys. (If “Error 15” is displayed, then there are no calibration factors stored. Perform subsection A.3.2.)

A.3.1.3 Checking the Reference Calibration Factor

A.3.1.3.1 Check the sensor module reference calibration factor by entering the following on the measuring receiver:

37.5 SPCL, (Blue Shift key), **MHz** key

A.3.1.3.2 If the measuring receiver displayed indication does not agree with the sensor module REF CAL FAC value, perform subsection A.3.2.1.

A.3.1.4 Checking the Frequency/Calibration Factor Pairs

A.3.1.4.1 Check the sensor module frequency/calibration factor pairs by repeatedly entering the following on the measuring receiver:

37.6 SPCL, (Blue Shift key), ⇧ **kHz** key (retrieves Frequency) (Blue Shift key) **MHz** (retrieves Calibration Factor)

A.3.1.4.2 If, at any time, the measuring receiver displayed frequency/calibration pair indications do not agree with the sensor module frequency/calibration data, perform subsection A.3.2.2.

A.3.1.4.3 Press the measuring receiver Green **AUTOMATIC OPERATION** key to the measuring receiver to normal operation.

A.3.2 Storing Calibration Factor Data

NOTES

If a miskey occurs during entry of frequency or calibration factor data, select the measuring receiver CLEAR key and continue.

All frequencies entered and displayed on the measuring receiver are in MHz.

A.3.2.1 Storing the Reference Calibration Factor

A.3.2.1.1 Enter the sensor module reference calibration factor by entering the following on the measuring receiver:

37.3 SPCL, (REF CAL FAC value), (Blue Shift key), **MHz** key

A.3.2.2 Storing the Frequency/Calibration Factor Pairs

A.3.2.2.1 Enter the sensor module frequency/calibration factor pairs by repeatedly entering the following on the measuring receiver:

37.3 SPCL, (Cal Factor Frequency, in MHz), **MHz** key (sets Frequency) (Cal Factor value), (Blue Shift key), **MHz** key (set Cal Factor)

A.3.2.2.2 The key sequence in step A.3.2.2.1 may be performed for any or all sensor module frequency/calibration factor pairs.

A.3.2.2.3 Press the Green **AUTOMATIC OPERATION** key to return the measuring receiver to normal operation.

NOTE

If performance of any portion of subsection A.3.2 was required, perform subsection A.3.1 prior to exiting this Appendix.